PPT Program Stakeholders Meeting, March 3, 2009

From Nanoparticles to Novel Protective Garments

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Presentation Outline

- Goal of the Project
- Current Technology and Its Limitations
- Phase I Work Plan
- Phase I Outcome
- Phase II Work Plan
- Acknowledgements

Project Goal and Envisioned Product

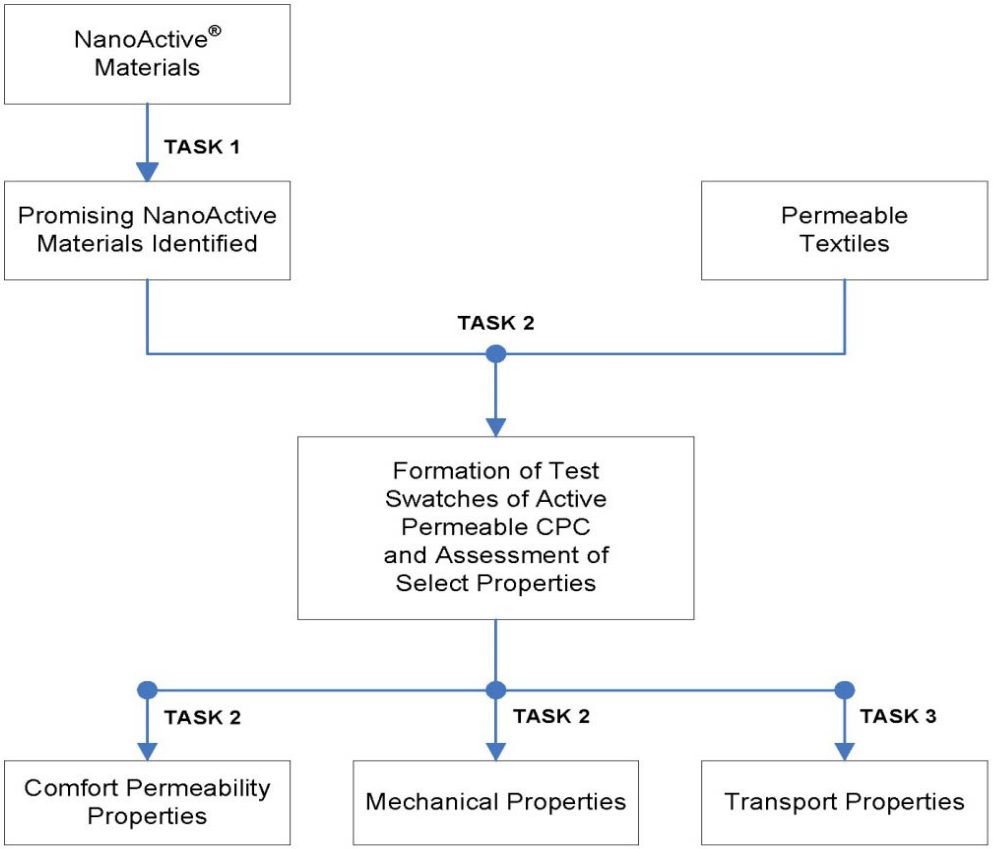
Prepare and test materials for clothing to protect against chemical hazards, particularly TICs.

- Protective
- Lightweight
- Air-permeable
- Comfortable

Current Technology and Associated Limitations

- Most of the chemical protective clothings are made of impermeable material resulting in heat stress.
- Protective textiles based on carbon materials need ***REAL*** enhancement.
- Only ***PARTIAL PROTECTION*** is afforded due to activated carbon by physical entrapment of toxins.
- Activated carbon ***DOES NOT NEUTRALIZE*** adsorbed chemicals; it simply stores them.
- Preferential adsorption of water by carbons or increase in temperature results in ***OFF-GASSING*** of adsorbed toxins.
- Untreated carbon has ***LITTLE EFFECT UPON ACID OR ALKALINE GASES.***

Phase I - Work Plan



Phase I – Key Conclusions

- NanoActive materials exhibit appreciable reactivity towards TICs.
- Both powders and granulated nano materials can be loaded onto textiles.
- Ammonia permeation performance of the textiles loaded with 88 g/m^2 of nano material is ***slightly less*** satisfactory than the control with 170 g/m^2 of activated carbon spheres.
- In chlorine permeation, permeable textiles containing nano materials show comparable protective performance to the carbon laminate.
- Approaches to make lightweight, air-permeable fabrics are feasible.
- Mixed formulations of nano materials should be developed to offer protection against a wide range of TICs.
- Agglomerated nano materials with ***increased hardness*** should be made to improve upon shedding problems.

Phase II - Work Plan

Task 1
Preparation of granulated mixed nanoparticles
Month 1 - Month 4

Task 2
Performance evaluation and down selection
Month 1 - Month 5

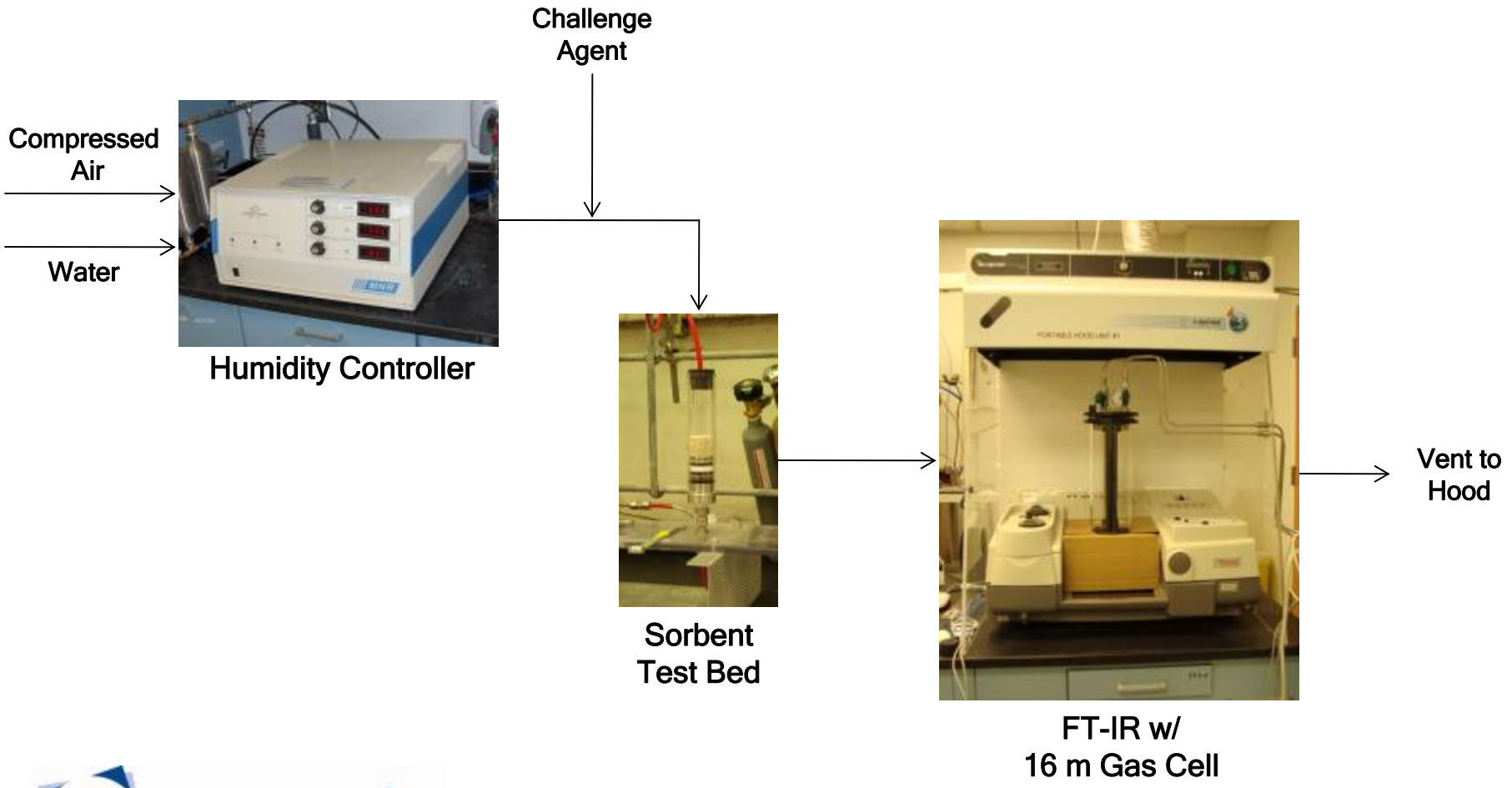
Task 3
Textile/nanoparticle integration/physical property measurement
Month 3 - Month 11

Task 4
Permeation testing
Month 6 - Month 12

Task 5
Scale-up studies
Month 13 - Month 17

Task 6
Prototype production
Month 18 - Month 24

Air Filtration Test Apparatus



Breakthrough Test Results

Sample	*NH_3*	*HCN*	*2-CEES*
1	5.5	17	21
2	6.9	20	32
3	7.3	*71*	29
4	5.5	1.0	12
5	7.3	*52*	41
6	3.0	*>180*	3.0
7	6.5	49	28

Sample	*NH_3*	*HCN*	*2-CEES*
8	5.5	*54*	19
9	7.3	25	24
10	5.0	12	23
11	*43*	6.5	*61*
12	34	22	36
13	27	30	38
14	21	45	34
Commercial	31	6.0	29

Breakthrough time in minutes.
Average of 3 trials.
Samples 4-6, and 11 are single metal oxides.
Samples 1-3 and 12-14 are bi-metal oxides.
Samples 7-10 are tri-metal oxides.

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Studies on Humidity Resistant Modifiers

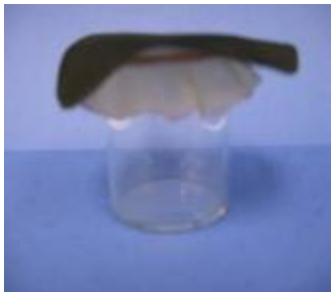
- Test sample:
  - Binary metal oxide.
- Humidifying conditions:
  - 75% humidity; 25°C; 24 h.
- Strongly hydrophobic modifiers from various classes of chemicals were used.
- Amount of water absorption was determined after humidification.
- Modified samples with <12% weight gain from water absorption were chosen for permeation tests.

Modifier	*Weight Gain, %*
None	24.7
P1	13.3
P2	15.2
P3	15.6
P4	8.9
P5	15.5
C1	1.8
C2	7.4
C3	1.9
C4	6.1
B1	12.4
B2	13.4
B3	12.5

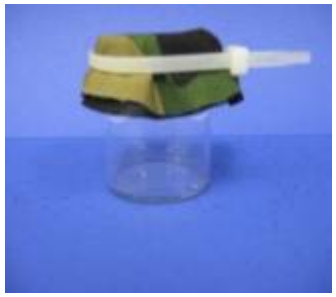
Permeation Test Set Up

Vessel + Comfort Layer

Vessel + Comfort Layer + Sorbent



Vessel + Comfort Layer + Sorbent + Black Liner



Vessel + Comfort Layer + Sorbent + Black Liner + Cover Fabric

- For DMMP testing: Water in inner vessel.
- For 2-CEES testing: Carbon beads in inner vessel and water in outer jar.

Complete Permeation Test Set Up

Progress to Date

- Multiple mixed formulations have been made.
- Hardness optimization is in progress.
- Humidity protection assessment is in progress.
- Performance testing is in progress.

Are We Doing the Right Science?

- Are scientific priorities aligned with societal needs?
  - ✓ Solicitation announcement by the agency
- Are there other plausible alternative approaches that might more effectively meet the needs?
  - ✓ Proposal submission, review, and ongoing literature updates
- "What we presently know" – Is that all "What we need to know?"
  - ✓ Novel materials and new technology with implications in various areas

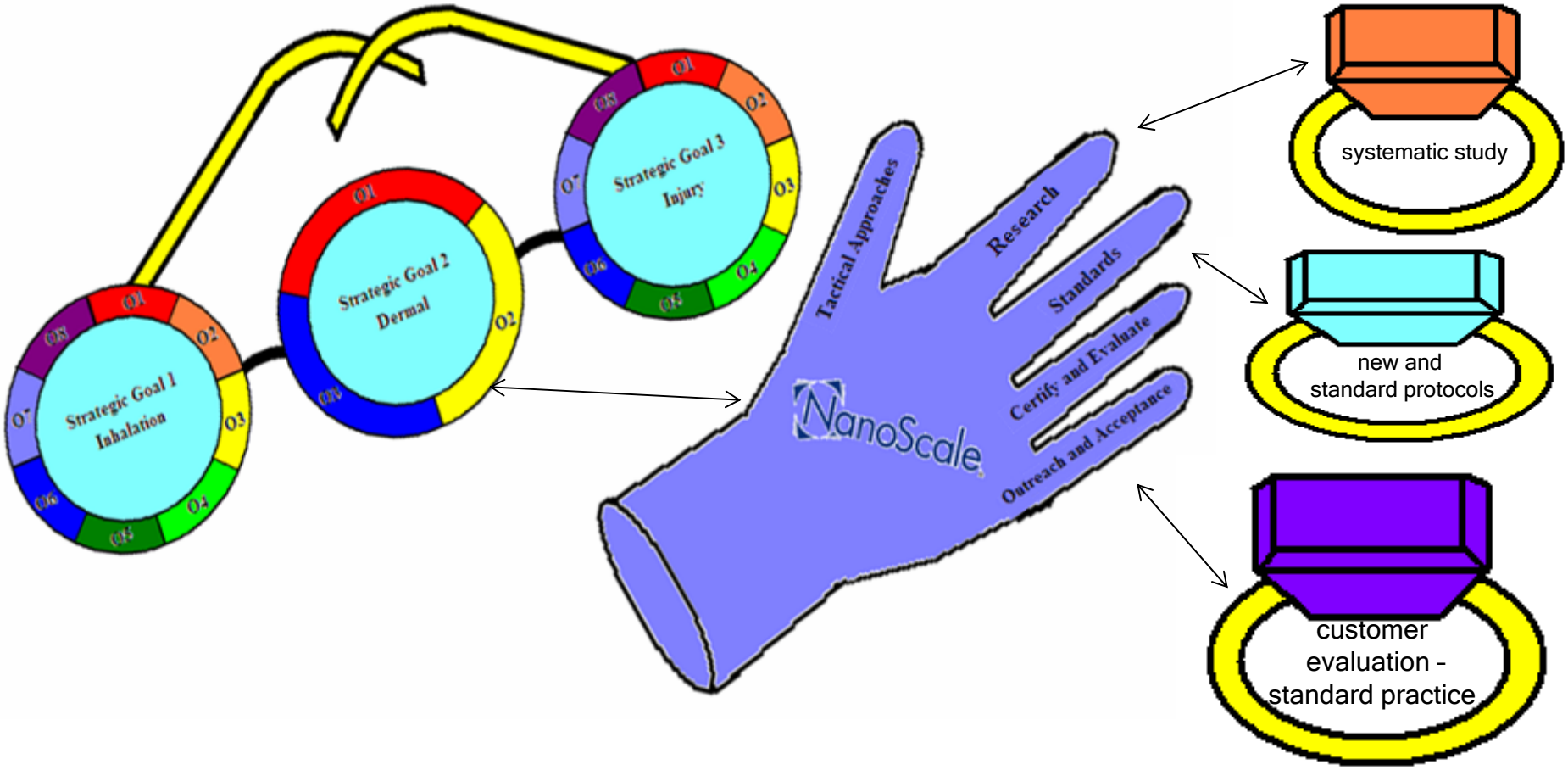
How Do We Know If We Are Doing the Right Science?

The Missed Opportunity Matrix

		DEMAND Can User Benefit from Research?	
		YES	NO
SUPPLY Is Relevant Information Provided?	NO		
	YES	Appropriate work plan; team effort with appropriate collaborator; prior commercialization experience; directed towards end-users from the start; has numerous wider implications in an evolving field.	

D. Sarewitz, R. A. Pielke, Jr., *Environmental Science & Policy*, **2007**, *10*, 5-16.

How Does the Current Funded Program Fit?



A Perfect Example of Use-Inspired Social Science

- The U.S. market for advanced protective clothing, armor, respirators and protective gloves now is valued at about $2.3 billion per year and is expected to increase to more than $3.35 billion by 2010, rising at an average annual growth rate (AAGR) of 7.9%.
- Chemical/biological exposure protection is valued at $340 million and is expected to increase at an AAGR of 8% through 2010, while ancillary gear is valued at more than $1.2 billion and expected to reach slightly over $1.6 billion by 2010.

SOURCE: http://www.mindbranch.com/Protective-Clothing-Gear-R2-1176/

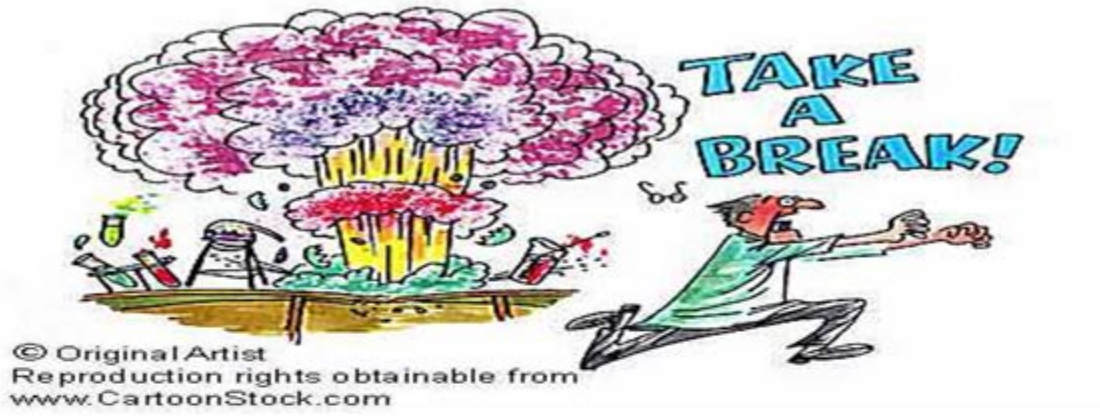
Acknowledgements

Team Members at NanoScale Corp.

Team Members at Gentex Corp.

CDC/NIOSH

FAIL-PROOF COMFORTABLE PROTECTION



YES, WE CAN